Frequency Counters

Integration Manual

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Cellocator Division
Pointer Telocation Ltd.

POINTER

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Table of Contents

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1 Introduction

This document describes the frequency measurement capability of the Cellocator Cello unit from firmware version 30e and on.

It includes detailed descriptions of the installation, calibration, configuration aspects and parsing of the received measurement on the server side.

1.1 Revision History

Version	Date	Description
30.0	12/10/10	Original version
30.1	19/10/10	Page 5 sec 2.2.1: signal amplitude range changed to 3-30V. Sec 2.2.2: rephrased
30e.1	4/11/10	Added Auto-Calibration description
30e.2	7/11/10	Added samples for Auto-Calibration OTA commands Fixed mistakes in Auto calculation equations on pages 6 and 11
30e.3	25/1/11	Tech Writer edited and formatted.
30e.4	13/2/11	All equations are synchronized with the same variables names convention. Engine speed renamed to engine rotation speed Vehicle's speed renamed to velocity Added notes, describing effect of calibration error on OTA measurement The calibration distance defined as 1km at least.
30.5	04/04/11	Change file name
31.0	10/08/11	Frequency counter threshold shall be programmed in scaled unit (RPM in case of engine rounds).

1.2 References

No.	Document Name	Version	Date	Remark
1	Cellocator Wireless Communication Protocol	v30a (rev2)	19/09/10	Or newer
2	Programming Manual Cello	30c4	5/10/10	Or newer

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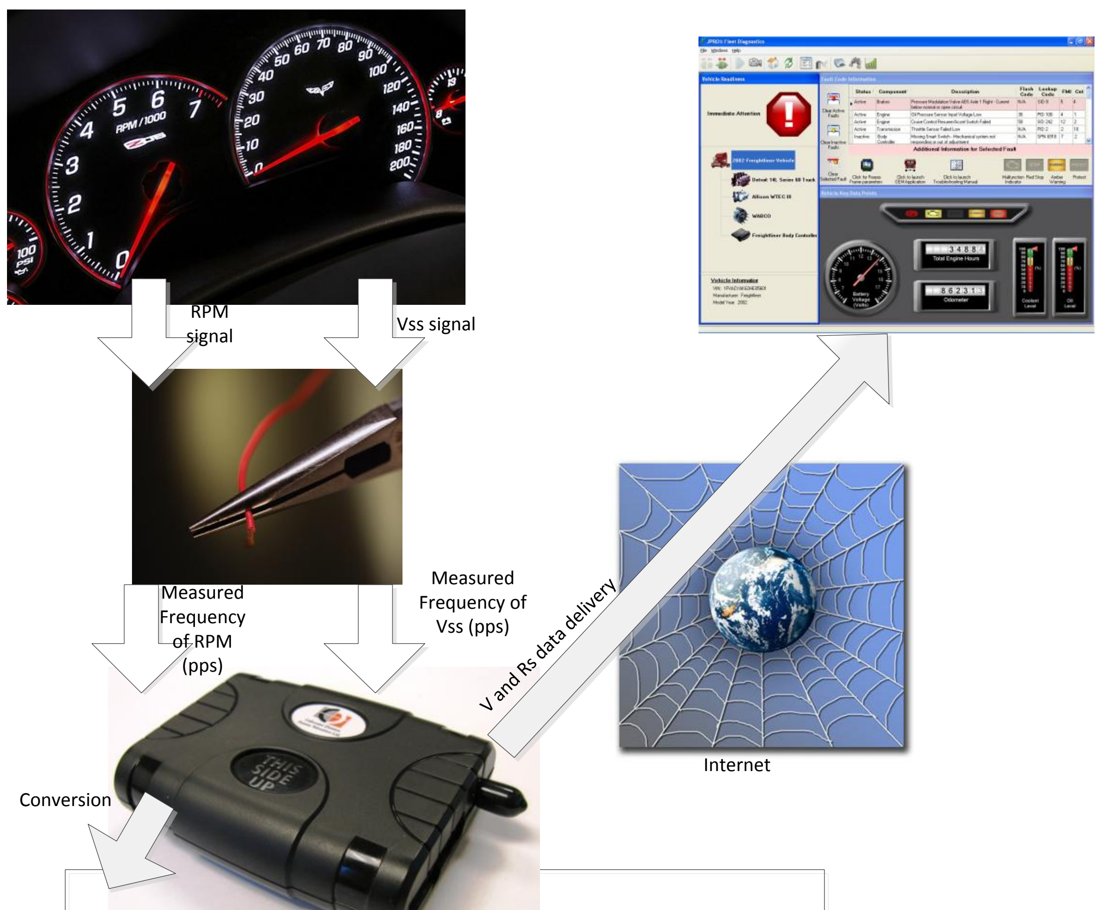
2 General

2.1 Overview

Frequency counter function provides a capability to monitor the frequency of any pulse based signal in a vehicle. Examples for pulse based signals are the RPM line, which carries pulses associated with the rpm of the engine of the vehicle and VSS (vehicle speed sensor).

The Cello unit can be configured:

- to monitor a measured frequency in any position message
- to generate a dedicated alert upon violation of pre-programmed threshold or range of the measured frequency
- to use measured frequency as a source of vehicle speed (instead of GPS signal)



$V[cm/sec]=Fv*Sv$
V – Momentary value of velocity [cm/sec]
Fv – Measured frequency of Vss
Sv – scaling factor of velocity

$Rs[rpm]=Fe*Sr$
Rs – Momentary value of Engine Rotation Speed [rpm]
Fe – Measured frequency of Vss
Sr – scaling factor of engine rotation speed

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The measured frequency is converted by the Cello unit into units of engine rotation speed, vehicle speed or any other units for convenient monitoring.

2.2 Hardware

Pulse frequency measurement is supported by a pair of multifunction inputs of Cello (pins 14 and 15, marked as "Door" and "Unlock2/SHOCK" respectively on installation harnesses 711-00196 and 711-00248). The unit can simultaneously measure frequency on both inputs.

2.2.1 *Signal Integrity*

The maximal possible frequency for measurement is 5 kHz; higher frequency causes saturation of the measurement.

The supported amplitude range of measured signal is between 3V to 30V, no negative signal is supported.

2.2.2 *Compatible Installation Harness*

If two frequency signals are measured simultaneously, shielded installation harness 711-00248 is required in order to prevent crosstalk between the lines.

Otherwise, if an unshielded installation harness is used while two frequency sources are connected concurrently, crosstalk between two lines will be generated and, as a result, measurement will be incorrect.

If only one signal is measured – standard installation harness (711-00196 or any available) may be used.

2.3 Preparation for Installation

2.3.1 *Frequency Conversion - General*

Different vehicles provide different pulse frequency per km/h and per engine rotation speed unit. The unit automatically converts measured frequency for convenient monitoring using a parameter called "Scaling Factor", provided separately for each of two inputs.

If measured frequency is programmed as a "speed source", the result of conversion will replace GPS speed in all the activity of the unit (like event generation algorithms, speed monitoring, etc). In this case the purpose of "Scaling Factor" is to convert frequency into units of cm/sec.

If measured frequency is programmed as a "general frequency source", the result of conversion will be continually monitored in a single byte field of position message. In this case the purpose of "Scaling Factor" is adaptation of the resolution of a monitored signal to fit the single byte field of Cellocator protocol. For example, if the maximum possible frequency of the specific signal is 4Khz, this value should fit single byte in the transmitted message – the resolution will be 4kHz/255=15Hz/bit.

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2.3.2 *Automatic Calibration Procedure*

2.3.2.1 RPM (or GP frequency) Input Calibration

Upon the completion of the installation, the installer switches on ignition, keeps the engine running on idle (for example on 700 rpm), and calls the operator and informs him of the current reading of the tachometer.

NOTE: Any mistake in RPM reading upon calibration process will cause a proportional error in future remote RPM reading.

If high accuracy of Engine Rotation Speed is required it is recommended to follow a manual calibration procedure, utilizing measurement of the RPM frequency using an Automotive Multimeter.

The operator sends RPM calibration OTA command, containing the reading reported by operator and number of frequency input. The unit measures a frequency from the RPM input, and calculates the best Scaling Factor for the corresponding engine rotation speed.

For example:

The idle engine rotation speed, according to the front panel, is 700rpm.

Maximum possible value of engine rotation speed in standard vehicle shall be assumed as 7000rpm, i.e. currently measured value is 10% of the maximum, and value of 10 is received in an incoming OTA command.

The measured frequency at the moment of OTA command reception is 400 Hz; therefore the maximum possible value is automatically set as 4000 Hz.

$$Fmax = \mathrm{Fc}\frac{100\%}{\mathrm{P}} = 400 * \frac{100\%}{10} = 4000(Hz)$$

Fc– measured frequency during calibration (Hz)

P – Percentage of a maximum value received in command (%)

Fmax – maximum possible frequency on the wire (Hz)

Using the values from the example above the Scaling Factor, adapting the resolution of the measurement will be calculated using the following equation:

$$Sr = 255\mathrm{FmaxSr} = \frac{255}{4000[\mathrm{pps}]} = 0.06375[\mathrm{pps/bit}]$$

Sr – scaling factor of engine rotation speed

Fmax – maximum possible frequency on the wire

(The value, automatically programmed in EEPROM upon the end of the calibration process, will be 64 - refer to the Programming section later in this document).

NOTE: Cellocator Programmer automatically adapts the value and shows it as 0.064.

2.3.2.2 Velocity (Vss) Input Calibration

The OTA speed calibration command shall only be sent while ignition is switched on.

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Upon reception of the OTA speed calibration command, the unit enters the pulse counting mode until next ignition off. During this mode the unit does not measure frequency on the specific input, but accumulates the number of pulses received during the entire driving period.

The driver will be asked by the operator to drive a certain distance (distance should not be shorter than 1KM); the same value of distance will be sent to the unit inside the OTA speed calibration command.

The driver will drive for the required distance according to the front panel reading, stop and switch off the ignition.

The unit will use the accumulated number of pulses to calculate the scaling factor as per the description below.

NOTE: The effect of inaccurate measurement decreases with increase of a calibration distance.

For example if the measurement error is 0.1km (normal deviation of the odometer scale on a front panel), it would cause a 10% error for 1km driving and only 2% for 5km driving.

Therefore it is very important to drive EXACTLY the distance sent in a command.

Example:

60.000 pulses accumulated during 5km.

$$Sv = \frac{\mathrm{D[cm]}}{\mathrm{Acc}} = \frac{500000\mathrm{[cm]}}{60000\ \mathrm{[pulses]}} = 8.333$$

D– Driven distance [cm]

Acc – Accumulated number of pulses

Sv – Scaling factor of velocity

(The value, automatically programmed in an EEPROM will be is 8333 - refer to Programming section later in this document)

2.3.2.3 Incoming OTA Calibration Command Structure

NOTE: Calibration command is replied, but ignored by the unit if Ignition switch is OFF when the command is received. The calibration will not be performed.

Type

0

The Command Code

0x14 – Calibration Command

Data field 1

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Contains description of the calibration type:

Reserved						Source type 0 – GP Freq. (RPM) 1 – Speed	Calibrated input 0 – pin 14 1 – pin 15
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

Data field 2

In case of GP Frequency contains percent of maximum engine load (i.e 10 for 10%)

In case of speed – required distance in hundred's meters (recommended value 5km).

Command Specific Data field

N/A

Example:

Speed calibration, source on pin 15, 5km calibration distance.

MCGP 00 *ID ID ID ID CN AU AU AU AU* 14 14 03 03 32 32 00 00 00 00 *CS*

RPM calibration, source on pin 14, 10% of maximum measured (700rpm)

MCGP 00 *ID ID ID ID CN AU AU AU AU* 14 14 00 00 0A 0A 00 00 00 00 *CS*

ID – Number of the target unit

CN – Command Numerator

AU – Command Authentication

CS - Checksum

2.3.2.4 Incoming Wire Calibration Command Structure

As a response to this command the unit shall reply with Generic Acknowledge Packet (Type 00h) or Generic Non-Acknowledge Packet (Type 01h).

NOTE: Calibration command is replied, but ignored by the unit if Ignition switch is OFF when the command is received. The calibration will not be performed.

Frequency Input calibration command (0x1E)

The message will contain the data fields as per the specification in a command.

Data part:

The data part of this packet has a size of 6 bytes.

The first byte contains a bitmask as described below:

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Reserved						Source type 0 – GP Freq. (RPM) 1 – Speed	Calibrated input 0 – pin 14 1 – pin 15
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

The Second byte contains:

- In case of GP Frequency contains % of maximum engine load (i.e 10 for 10%)
- In case of speed – required distance in hundred meter values (recommended value 5km)

Third-six's bytes are reserved, sent as zeros.

2.3.3 *Manual Calibration Procedure*

It is also possible to perform a calibration manually, using Automotive multi-meter, although it is recommended to follow an automatic procedure.

2.3.3.1 Automotive Multimeter

In case of a manual calibration, prior to an installation it is necessary to know the range of the signal and, in cases of speed, the exact conversion factor.

NOTE: Setting an incorrect factor will either cause an incorrect speed reading or, in cases of general frequency metering, suboptimal resolution of the measurement.

The easiest way to measure the frequency of the signal is by using an Automotive Multimeter capable of measuring frequency, such as the TECPEL DMM-8088 or similar.

2.3.3.2 Discovering the Scaling Factor for Velocity

The idea of the test is to find a relation between the frequency of pulses on Vss wire and a vehicle's speed.

The scaling factor for speed is discovered during the driving session. There are 2 options:

- Using the Automotive Multimeter, connected directly to the Vss wire and continually measuring frequency.

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- Using the unit's Frequency measurement of the Cello unit, connected to the Vss wire and continually monitoring frequency in OTA messages. The same messages also contain the speed estimated by GPS. If this method is used, the input connected to the Vss wire should be configured as GP Freq. counter, scaling factor of 0.25 (maximum Vss value is 1kHz).

The driver should stabilize vehicle's speed at a certain value and write down the frequency measured for this speed.

The test should be repeated for different speeds, to validate the result.

Example: When calibrating a vehicle at 40 Km/h (1111 cm/s), the measured frequency obtained is 54 pulses per second. When the system measures 108 pulses/second, we can assume the vehicle is running at 80 Km/h (2222 cm/s).

Using the values from the example above the scaling factor will be calculated using the following equation:

Sv= V[cm/sec]/Fv; => $Sv = \frac{1111[\frac{cm}{s}]}{54[pps]} = 20.576$

V – Momentary value of speed [cm/sec]

Fv – Measured frequency of Vss

Sv – scaling factor of velocity

2.3.3.3 Discovering the Scaling Factor for Engine Rotation Speed

The ideas of the test are:

- To find a relation between frequency of pulses and the RPM number shown by the odometer, in order to show the correct value in Central Control application.
- To discover the maximum possible frequency to define the resolution of the monitoring.

The scaling factor for speed is discovered by monitoring the pulse frequency on RPM wire by Automotive Multimeter and finding the frequency representing specific RPM values.

The driver should stabilize engine rotation speed at a certain value and write down the frequency measured for this engine rotation speed.

The test should be repeated for different engine rotation speeds, to validate the result.

Example: When vehicle odometer shows 700rpm, the measured frequency (according to the Automotive Multimeter) is 400 pulses per second. When the odometer shows 1400 rpm, we can assume the measured frequency will be 800pps.

Assuming that the maximum possible engine rotation speed in a standard vehicle is 7000 rpm, the maximum possible frequency on this wire will be 4000 pps.

Using the values from the example above the Scaling Factor, adapting the resolution of the measurement will be calculated using the following equation:

$\mathrm{Sr} = \frac{255}{\mathrm{Fmax}} = \frac{255}{4000[\mathrm{pps}]} = 0.06375[\mathrm{pps/bit}]$

Sr – scaling factor of engine rotation speed

Fmax – maximum possible frequency on the wire

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The central control will have to apply a different conversion upon parsing of the received value, as it has to convert it to the real engine rotation speed and not to the frequency of the representing pulses measured by the unit.

$$Rs[rpm] = Xes * \frac{7000}{255}[rpm]$$

Rs – Momentary value of engine rotation speed [Hz] (this value is received in an OTA response to calibration command)

Xes – value representing Engine rotation speed, received in the message

7000 – max possible value of RPM

255 – max possible value representing Engine rotation speed, received in the message

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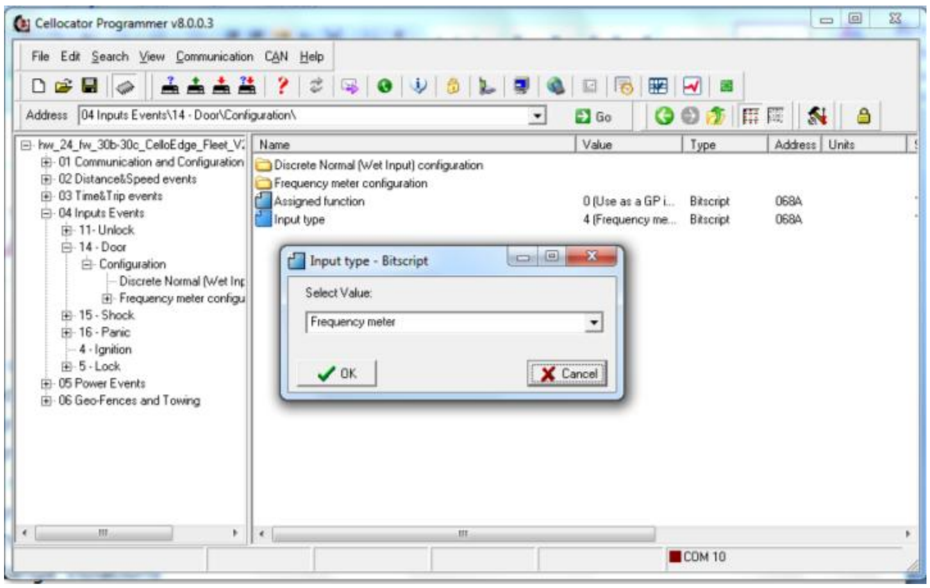
2.4 Programming

2.4.1 *Selecting Input Type*

Two of the unit's inputs allow frequency measurement: 14-Door and 15-Shock.

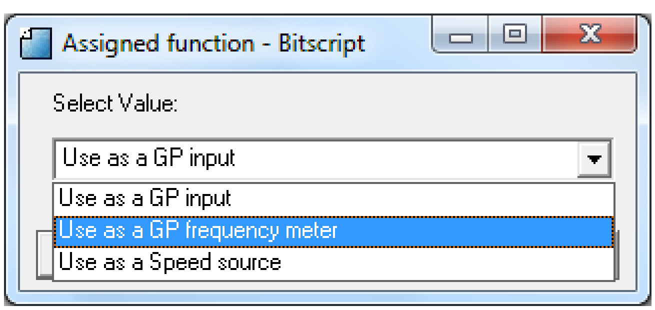
In the Configuration folder of those inputs (04 Inputs Events\14 - Door\Configuration\) Input Type shall be chosen as Frequency Meter.



NOTE: Enabling frequency measurement disables any other functionality of the input; obviously only one of these functionalities can be active at a time.

2.4.2 *Selecting Assigned Function*

The Assigned Function parameter appears in the same folder. It shall contain a type of Frequency Source: Speed or Engine rotation speed (GP Frequency).



NOTE: If both inputs are programmed as frequency counters, the signal from 14-Door input will be considered as speed and from 15-Shock input as general purpose.

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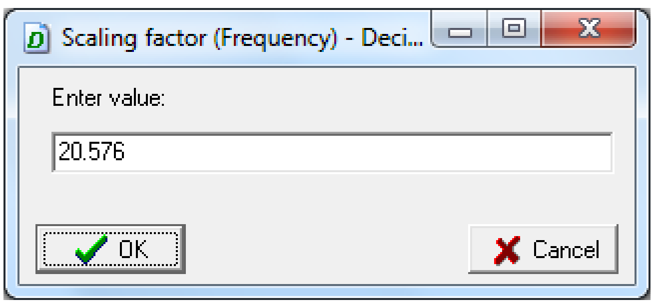
2.4.3 *Programming Scaling Factor*

NOTE: The scaling factor is calculated by the unit and programmed automatically during Automatic Calibration Procedure.

IMPORTANT! Make sure to upload the auto-calculated value of Scaling Factor from the unit after Automatic Calibration Procedure. This is in order to prevent overwriting or erasing of this parameter during programming of a PL that does not contain this value.

The "Frequency meter configuration" folder of input's configuration (04 Inputs Events\14 - Door\Configuration\Frequency meter configuration\) contains the Scaling factor parameter.

Enter the Scaling Factor for each input as described in section 2.3.



2.4.4 *Programming Location of the Frequency Measurement in OTA Message*

The OTA protocol provides 4 bytes dedicated for monitoring of analog/frequency inputs in a few different message types. These bytes can contain measurements from different sources, such as batteries, temperature, voltage and frequency.

In Inputs Configuration folder of PL (01 Communication and Configuration\Inputs&Outputs\Analog&Frequency in OTA message\) it is possible to set the content of the specific bytes.

The input, connected to a GP Frequency signal (14-Door or 15-Shock), shall be selected for one of the bytes.

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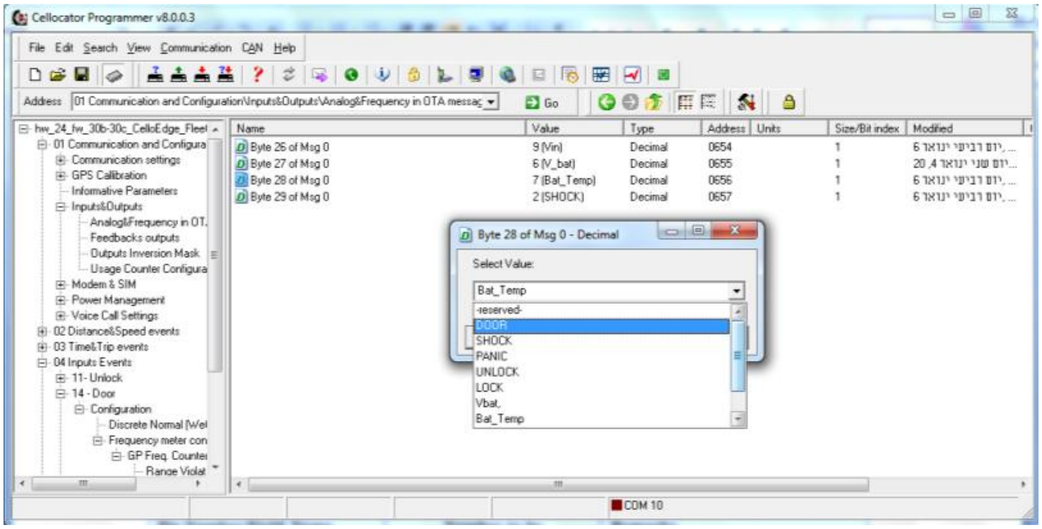

2.4.5 *Programming Active Alerts*

It is possible to program the unit to generate an active alert with transmission reason d192 (logged event or distress) upon violation of certain threshold or range. The specific message also contains the Specific TR field, clarifying the reason for the transmission.

2.4.5.1 Threshold Violations

From the "GP Freq. Counter Violation settings" folder (04 Inputs Events\14 - Door\Configuration\Frequency meter configuration\GP Freq. Counter Violation settings\) chose Violation type as "Threshold".

In Threshold Violation Setting Folder of each input (04 Inputs Events\14 - Door\Configuration\Frequency meter configuration\GP Freq. Counter Violation settings\Threshold Violation Setting\) configure the required threshold.

- Threshold Type (Low or High)
- Time Filter for frequency violation (time of continuous violation in seconds before message generation)
- Frequency Threshold Low and Threshold High signal in scaled unit (RPM in case of engine rounds).

NOTE: The frequency threshold (unlike the threshold of Analog input) is applied on the scaled value and not on the measured value. The threshold is applied on General Purpose Pulse measurement input only.

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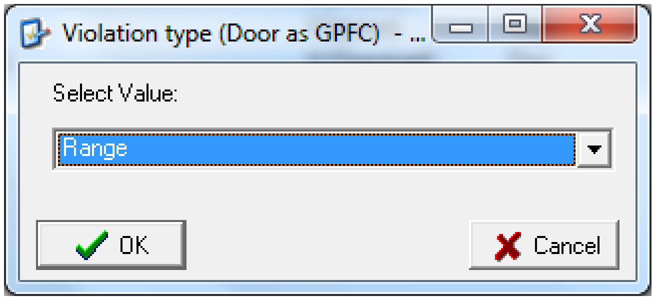
2.4.5.2 Range Violations

From the "GP Freq. Counter Violation settings" folder of required input (04 Inputs Events\14 - Door\Configuration\Frequency meter configuration\GP Freq. Counter Violation settings\) chose Violation type as "Range".



In Range Violation Setting Folder of each input (04 Inputs Events\14 - Door\Configuration\Frequency meter configuration\GP Freq. Counter Violation settings\Range Violation Setting\) configure the required high and low thresholds of the required range.

- Range Type (Keep in or Keep Out)
- Time Filter for frequency violation (time of continuous violation in seconds before message generation)
- Frequency Threshold Low and Threshold High signal in scaled unit (RPM in case of engine rounds).

NOTE: The frequency range (unlike the range of Analog input) is applied on the scaled value and not on the measured value. The range is applied on General Purpose Pulse measurement input only.

2.4.5.3 Other Settings

From the GP Freq. Counter Violation settings folder (04 Inputs Events\14 - Door\Configuration\Frequency meter configuration\GP Freq. Counter Violation settings\) it is possible to program:

- Delivery type (Event or Distress)
- Violation session (alert for start violation and for end of violation separately)
- Cancelation of timeout for violation end
- Cancelation of violation alert that might be generated on boot

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2.5 Parsing Received Data in Central Control

2.5.1 *Parsing Speed from OTA Message*

The speed from Vss input replaces standard GPS speed in all the messages generated by the unit. It is reported in the same units as legacy GPS speed; there is no need for any adaptation of the server side.

The unit monitors and reports the speed source in:

- The OTA msg type 0: Byte 16, bit 3
- The OTA msg type 9, Byte 16, bit 3
  - 0 – GPS
  - 1 – Pulse frequency input

2.5.2 *Parsing Frequency Measurement*

If the input is defined as a General Purpose pulse frequency measurement, the system is continually measuring frequency on this input (while not in full hibernation) and monitoring the value of this input after conversion.

In case of Engine rotation Speed measurement:

The central control will have to apply the following conversion upon parsing of the received value, in order to convert it to the real engine rotation speed.

$\mathrm{Rs[rpm]} = \mathrm{Xes} * \frac{7000}{255}$[rpm]

Rs – Momentary value of engine rotation speed [Hz] (this value is received in an OTA response to calibration command)

Xes – value representing Engine rotation speed, received in the message

7000 – max possible value of RPM

255 – max possible value representing Engine rotation speed, received in the message

2.5.3 *Range or Threshold Violations*

The alerts upon violation of Range or Thresholds are generated as events or distress messages with transmission reason d192, specific transmission reason fields as follows:

<table>
<tr><td rowspan="2">Violating input number

0- Door
1- Shock</td><td rowspan="2">Violation status

0 – Violation start
1 – Violation End</td><td rowspan="2">Violation type

0 – Threshold

1 - Range</td><td>Violation direction

In case of Threshold
0 – Low thresh.
1 –High thresh.</td><td colspan="4" rowspan="2">Reserved</td></tr>
<tr><td>In case of range
0 –Keep In
1 – Keep Out</td></tr>
<tr><td>Bit 7</td><td>Bit 6</td><td>Bit 5</td><td>Bit 4</td><td>Bit 3</td><td>Bit 2</td><td>Bit 1</td><td>Bit 0</td></tr>
</table>

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